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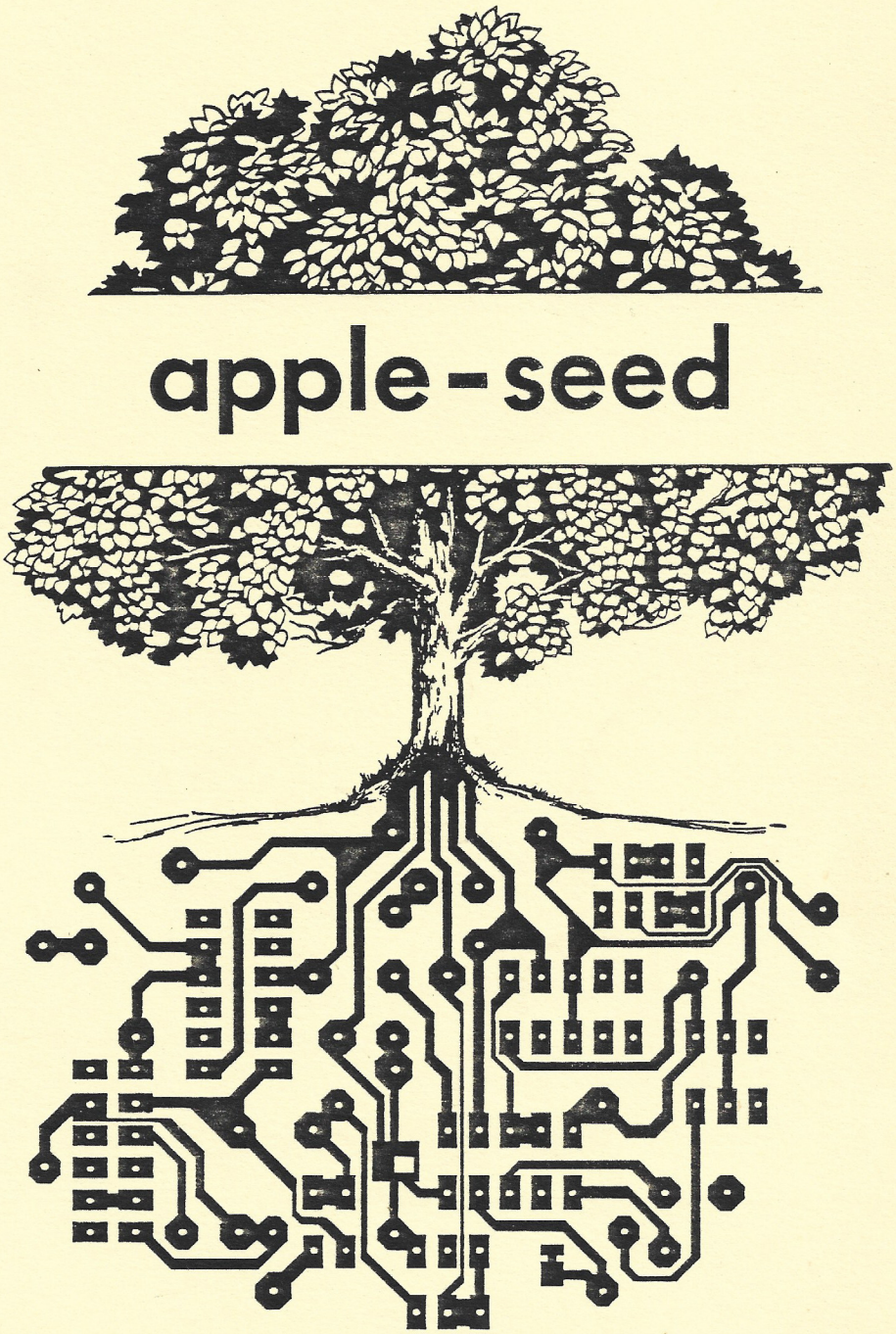
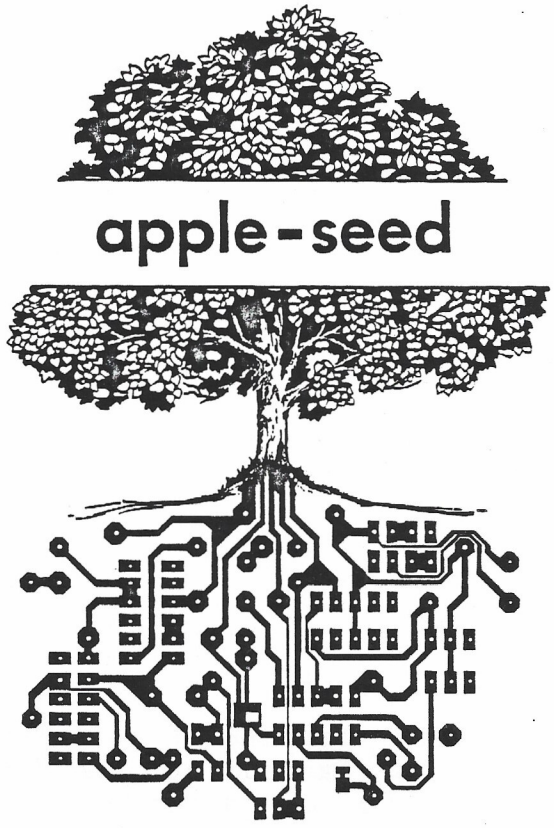


apple-seed

AN INTRODUCTORY GUIDE TO THE TECHNIQUES OF ASSEMBLING APPLE™ COMPATIBLE AND OTHER MICROCOMPUTERS

BY
RAYMOND KOSMIC



BY RAYMOND KOSMIC

Also by Raymond Kosmic

Surf-Board: Assembly Manual for the 6502-based Microcomputer
Apple-Seed: Peripheral Card Assembly Manual

Published by NuScope Associates
Willowdale, Ontario,
Canada

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Post Office Box 742,
Station B,
Willowdale, Ontario,
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To Andrea

PREFACE

This manual was designed to be used as an educational guide for the construction and assembly of electronic devices such as computers that use printed circuit boards, integrated circuits, and electronic components. Because of its availability and popularity, the Apple™ microcomputer was chosen to illustrate the fundamental tehniques associated with the assembly of a computer. No previous knowledge or experience is required. The role of electronic components in this guide is simply and briefly introduced without resorting to complicated theoretical and mathematical relationships often erroneously associated with electricity and electronics. The installation instructions in this self-directing guide are presented in a simple step-by-step sequence and written with the first time hobbyist or novice enthusiast in mind. It is strongly recommended that you examine an operational microcomputer and study this guide before attempting your personal assembly project.

The author would welcome any criticism or suggestions that would improve this guide.

ACKNOWLEDGMENTS

I wish to express my appreciation to John, my son, for introducing me to the world of computers and for assembling the computer in such an expert and professional manner; to Joseph L. Sutherland, Toronto, and Jerry R. Senczuk, East York, whose valuable assistance and expert technical advice were instrumental in the completion of this manuscript; to Nigel Sky, Scarborough, a friend and associate, and Natalie, my wife, for being gracious enough to review the manuscript, and to make crictical recommendations and corrections.

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1.

INTRODUCTION

CHIPS

ICs

The circuitry of a computer consists of millions of electronic switches that are arranged to perform operations and make decisions. These switches, actually microscopic transistors which are caused to be turned on and off, are packaged in a case called an integrated circuit (IC) . ICs are complete miniature circuits on small wafers or chips of nearly pure silicon. These chips, less than one centimeter on each side and about half a millimeter thick, contain thousands of miniature electronic components, mostly transistors, housed beneath the surface. A grid of small metallic strips act as electronic connectors and are located on the surface of the chip. These connect the chip to the outside world. Most ICs are dual in-line packages (DIPs) and are embedded in plastic or ceramic. Pins from each side of this package interconnect the micro-miniature circuit to other components of the computer.

CPUs

The electronic brain of the microcomputer lies in the central processing unit (CPU), is often referred to as the microprocessing unit (MPU), and performs arithmetic and logic operations on information or data presented to it. In other words, the CPU controls the rest of the microcomputer and is responsible for all the "computing" that is done.

Two factors determine the computing ability of the CPU: a) the word size and b) the frequency of its "clock".

a) The 6502 MPU has a data path or word size of eight bits (8-bit processor) and is at the heart of all Apple™ and Apple™ compatible microcomputers.

b) The circuitry of the electronic clock synchronizes the operations of the computer. The 6502 MPU runs at a frequency of 1.023 megahertz, i.e., 1,023,000 machine cycles per second, and can do 500,000 additions and subtractions in one second.

ROMS and RAMS

A computer cannot operate without memory. Memory is required to store data, instructions, programs, and is used as a work pad for calculations. Two kinds of memory are available to computers: ROM (Read-Only-Memory) and RAM (Random-Acess-Memory).

ROM ICs contain instructions and programs that are immediately available to the user when the power is turned on. ROMs store programming languages such as BASIC, Pascal, etc. Information is permanently written into ROM by the manufacturer. Neither can new data be written into ROM, nor can information stored in ROM be altered. ROMs do not lose their data when the power to the computer is turned off.

PROMs are programmable ROMs that can be programmed by the user. One can write a desired set of instructions into a PROM. However, once the program is "burned" into a PROM, it cannot be reprogrammed.

EPROMs are erasable PROMs that can also be programmed by the user. Information contained in the EPROM, however, can be erased when ultraviolet light of a specific wavelength is directed into the quartz window which lies on top of the IC. The EPROM can then be reprogrammed. The 6502 board described in this guide requires seven 2716 EPROMs of which one is a character generator. These ICs can be programmed with an EPROM programmer according to the wishes of the individual.

EEPROMs (Electrically Erasable PROMs) can be erased using electrical signals rather than ultraviolet light.

RAM (Random-Access Memory or read/write memory) is the second kind of memory available to computers. Programs, information, and data can be written into RAM from an external source and then read out as often as needed. However, RAM ICs lose their data when the electrical power to the computer is turned off. A total of twenty-four 4116 dynamic RAMs (200 nanoseconds or faster) populate the 6502 board giving the microcomputer a total of 48 kilobytes of user memory. This can be increased to 64 K of memory with the addition of a 16 K RAM card installed in peripheral slot zero (Ø).

TTLs, CMOS and MOS

ICs are classified according to their internal structure. Three basic technologies, currently in use, are TTL (Transistor-Transistor-Logic), CMOS (Complementary Metal-Oxide-Silicon) and MOS (Metal-Oxide-Silicon).

Most of the chips on the 6502 board are TTLs. Some of the TTLs that populate the 6502 board start with the designation "74LS..." where LS refers to "Low-power Schottky". The two or three numbers that follow "LS" designate the specific function of that particular TTL.

CMOS and MOS ICs are highly susceptible to static discharge and must be handled with special care. MOS devices used on the 6502 board include the CPU, EPROMs, and RAMs.

2.

GETTING STARTED

TOOLS

1. SOLDERING IRON AND STAND: Consider buying a high-quality soldering iron; it's your most important tool. Look for a low-wattage iron (less than 35 watts) with a 3-wire grounded plug. A small soldering iron tip or "bit" is preferred as the conductor lines or traces are narrow and spaced close together. Select an iron with interchangeable tips (Fig. 2-1).

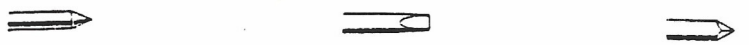


Fig. 2-1. SOME INTERCHANGEABLE SOLDERING IRON TIPS OR BITS.

2. SOLDER: Use small-diameter (1.0 to 1.5 mm) rosin core radio-type solder with a 60/40 or 63/37 tin/lead content. NEVER use acid core solder.

3. WIRE CUTTER AND STRIPPER: Chose one with an adjustable stop. A self-opening spring, although not a necessity, may save time in the long run.

4. DIAGONAL CUTTING PLIERS: Good quality cutting pliers are required to cut and trim wire leads of components such as resistors, capacitors, etc.

5. NEEDLE-NOSED PLIERS: Purchase miniature pliers about 10 to 14 cm long. These are used to hold and bend wire leads of various electronic components.

6. INTEGRATED CIRCUIT EXTRACTOR: This important tool,shown in Fig. 2-2, is used to gently remove integrated circuits from their sockets without damaging them. Can be used on chips with 8 to 24 pins.

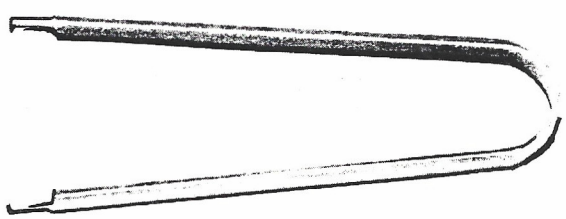


Fig. 2-2. AN INTEGRATED CIRCUIT EXTRACTOR.

7. SCREWDRIVER: Select a small screwdriver about 10 to 13 cm long with a narrow 3 to 4 mm wide blade. A nail file or a small jeweller's screwdriver can be used to check whether or not ALL the pins of a socket have gone through ALL the holes in the circuit board.

8. MAGNIFYING GLASS: May be helpful when checking for solder bridges or reading the numerical values on small capacitors and transistors.

9. ADJUSTABLE LIGHT STAND: There's less chance of error when working under proper lighting conditions.

SAFETY

1. When cutting excessive wire leads from resistors, diodes, etc., protect your eyes. Either wear safety glasses or keep the board at a distance and turn your head away from the board when trimming component leads.

2. Treat the soldering iron with respect. A hot iron can inflict a nasty burn.

3. Do not touch soldered connections before they have cooled down.

4. Always rest the hot iron on a soldering stand when not in use.

5. Turn the soldering iron off when you leave your work area.

6. Work in a well-ventilated area.

7. Observe all electrical and fire safety precautions.

8. There's less chance of accident if your work area is clean and well organized.

THE ART OF SOLDERING

PRACTICE MAKES PERFECT

Your last electronic project may have been several years ago when you put together that hi-fi pre-amplifier or receiver. Or, you may be one of the many who has never soldered before. If so, then I strongly urge you to practice the art of soldering before tackling the main board.

Ask your electronics dealer for part of a used or discarded printed circuit board. Buy a few resistors, a capacitor, and one or two 14-pin solder tail sockets and try your hand at soldering. Soldering, although an art, can quickly be mastered. A short practice session will soon make you as expert. You'll quickly master the technique and attack the real thing with confidence and enthusiasm.

I would like to see one of the suppliers put together a "soldering practice kit" that could be sold by retailers for a reasonable price. This kit should contain a pre-drilled circuit board, a few resistors and capacitors, one or two sockets, and a 15 cm length of solder. Make your mistakes on the practice board rather than on the main board.

THE ELECTRICAL CONNECTION

One of the most fundamental aspects of assembling any circuit board is soldering. Solder forms an electrical connection beween a component wire lead and the foil. The foil then links components to one another. A poorly soldered connection impedes the flow of electrons and thus renders the board inoperative.

Double-sided printed circuit boards have conductor lines or traces on both sides of the board. "Plated-through" holes connect the traces located on the UPPER surface (referred to as the COMPONENT SIDE in this text) to the traces on the LOWER surface (referred to as the SOLDER SIDE) of the board. Pins of sockets or wire leads of electronic components are pushed through the plated-through holes and soldered to the solder side of the board.

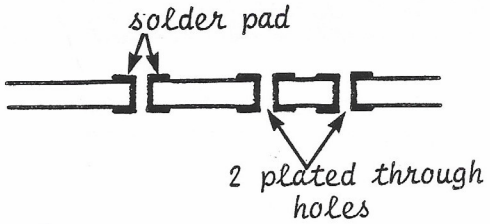


Fig. 2-3. PLATED-THROUGH HOLES CONNECT THE UPPER AND LOWER SURFACES OF THE PRINTED CIRCUIT BOARD.

CAUTION AN ABSOLUTE REQUIREMENT OF THE 6502 BOARD IS THAT ALL COMPONENTS ARE INSTALLED ON THE COMPONENT SIDE OF THE BOARD (FIG. 2-4) AND SOLDERED TO THE SOLDER SIDE (FIG. 2-5).

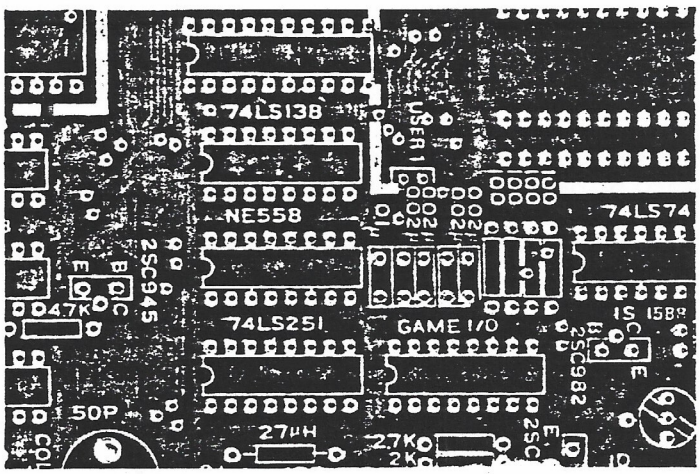


Fig. 2-4. A PORTION OF THE COMPONENT SIDE OF A PRINTED CIRCUIT BOARD SHOWING THE COMPONENT LAYOUT. NOTE THE SOLDER PADS AND THE SILK-SCREENED LABELS.

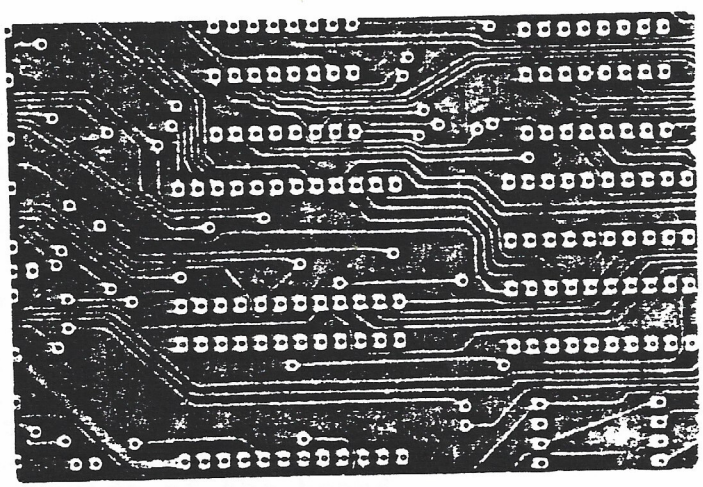


Fig. 2-5. A PORTION OF THE SOLDER SIDE OF A PRINTED CIRCUIT BOARD SHOWING THE FOIL PATTERN. A SOLDERING IRON WITH A SMALL TIP IS REQUIRED AS THE TRACES ARE NARROW AND SPACED CLOSE TOGETHER.

THE WAY IT'S DONE

This section introduces basic skills associated with soldering. Subtle tricks and speed come with practice and experience.

1. Use a damp sponge or cloth to clean the tip of the soldering iron. It is essential that the tip of the iron is first "tinned", i.e., some solder is melted onto the tip to give it a smooth, wet, shiny look.

2. Use a very small amount of solder. Microcomputer parts are small and the conductor lines are spaced close together.

3. Think in terms of a three-point contact:

"TIP-PIN-FOIL"

4. Firmly push the TIP of the soldering iron against both the socket PIN (or wire lead of the component) and the FOIL as shown in Fig. 2-6. Apply heat for ONE to TWO seconds.

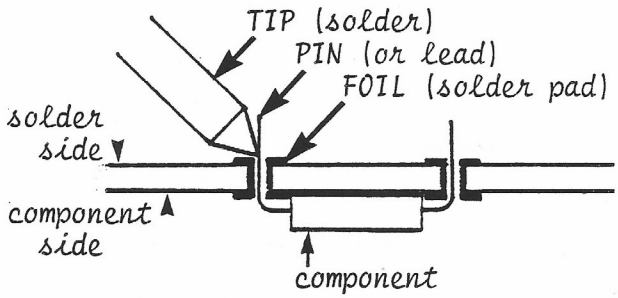


Fig. 2-6. THREE-POINT CONTACT.

5. Apply solder to the opposite side of the pin touching both the pin and the foil (Fig. 2-7). The solder should not touch the soldering iron tip. Heat from the iron will be transferred along the foil and the pin to the solder and melt it. The melted solder will flow evenly
a) around the connection and
b) into plated-through hole to the other side of the board.

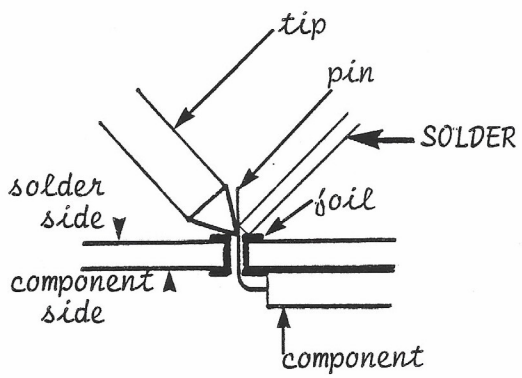


Fig. 2-7. APPLYING SOLDER TO THE OPPOSITE SIDE OF THE PIN.

6. Lift the solder from the connection BEFORE removing the iron.

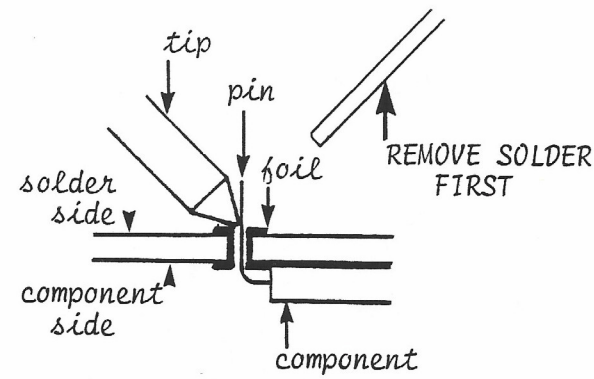


Fig. 2-8. REMOVING THE SOLDER BEFORE THE IRON.

7. Finally remove the soldering iron by sliding it UP along the pin (Fig. 2-9). Do not touch or move the newly-formed connection until it has cooled and solidified. Examine the connection; it should be smooth, shiny, and "mountain-shaped". Turn the board over and examine the solder joint on the opposite side for excess solder build-up, a common error. Without realizing it, such solder build-up may result in a solder bridge between two adjacent traces.

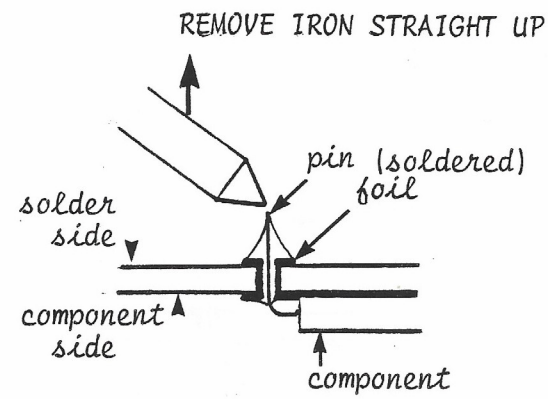


Fig. 2-9. REMOVING THE IRON UP ALONG THE PIN.

8. This whole process should take no more than 3 to 4 seconds. Excessive heat may damage delicate diodes, transistors, etc. On the other hand, too little heat may result in a "cold solder", a dull-gray,cracked, pitted connection.

9. The four basic steps to correct soldering are:

IRON ON - SOLDER ON - SOLDER OFF - IRON OFF

SOLDERING ERRORS TO AVOID

The following illustrate some common errors associated with soldering. AVOID them.

1. Error: IRON-FOIL CONTACT ONLY.

   The iron tip does not make contact with the pin (Fig. 2-10).

   Result: A POOR CONNECTION.

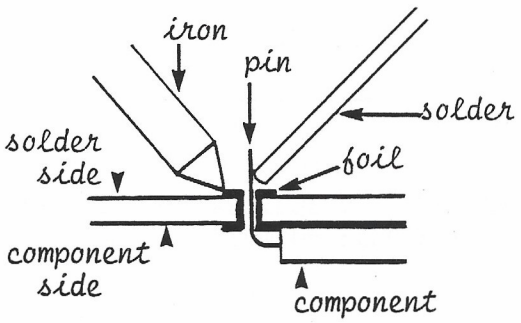


Fig. 2-10. AVOID IRON-FOIL CONTACT ONLY.

2. Error: IRON-PIN CONTACT ONLY.

   The soldering iron tip does not make contact with the foil (Fig. 2-11).

   Result: A POOR CONNECTION.

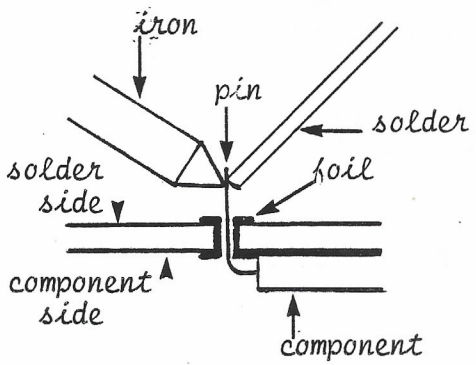


Fig. 2-11. AVOID IRON-PIN CONTACT ONLY.

3. Error: SOLDER-IRON CONTACT ONLY.

   The solder makes contact only with the iron (Fig. 2-12).

   Result: A POOR CONNECTION.

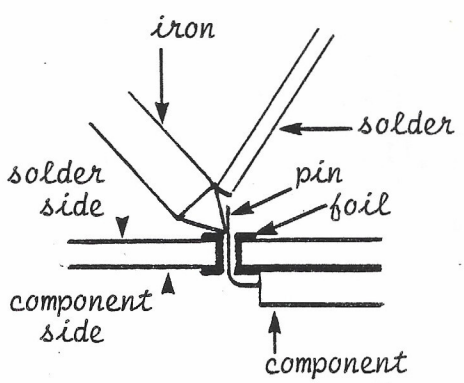


Fig. 2-12. AVOID SOLDER-IRON CONTACT ONLY.

The preceding errors may result in a "tear-drop" shaped blob of solder sitting on top of solder residues (fluxes) and air spaces that may act as electrical insulators (Fig. 2-13).

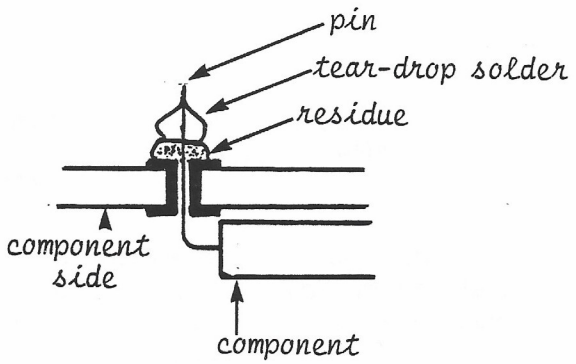


Fig. 2-13. RESIDUE MAY PREVENT THE FLOW OF ELECTRONS.

4. Error: IMPROPERLY-INSERTED SOCKET PIN.

A folded-under pin may not take the solder. Furthermore, the bent pin could cause a short circuit if it makes contact with an adjacent trace (Fig. 2-14).

Result: A SHORT CIRCUIT.

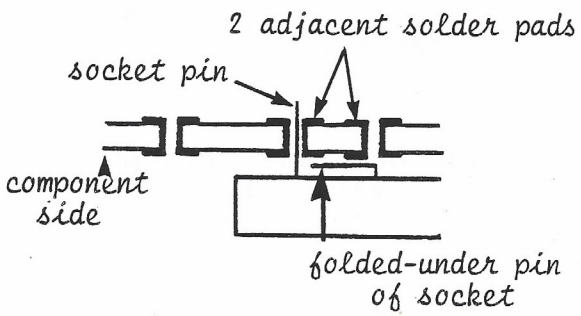


Fig. 2-14. AVOID FOLDED-UNDER PINS OF SOCKETS.

5. Error: DRAGGING THE IRON ACROSS THE TRACES.

Remove the soldering iron STRAIGHT UP along the pin. Dragging the iron across the traces may sweep some unwanted solder across to an adjacent trace or component lead.

Result: A SHORT CIRCUIT.

Both sides of the board have a protective coating between the traces known as "solder resist" or "solder mask". This insulation prevents, to a certain extent, solder bridges from forming.

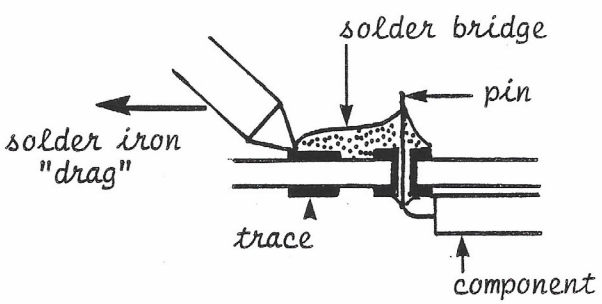


Fig. 2-15. AVOID DRAGGING THE IRON ACROSS THE TRACES.

REMOVING SOLDER BRIDGES

CAUTION ALL METHODS USED TO REMOVE SOLDER BRIDGES CREATE A GREAT DEAL OF HEAT WHICH CAN DAMAGE THE PRINTED CIRCUIT BOARD.

Excessive heat over a prolonged period of time may cause the traces to separate from each other and the board. The methods suggested should be employed quickly and carefully. The soldering iron must be thoroughly cleaned of all excess solder before attempting any one of the following methods.

1. Clean the iron. Heat the solder bridge so that some of the unwanted solder flows by capillary action onto the tip of the iron. Remove the iron and clean the tip on a damp sponge. Let the area cool and repeat, if necessary.

2. CAUTION: PROTECT YOUR EYES.

   Clean the iron. Position the board above your head, solder side down. Apply heat to the bridge and let the melted solder flow down onto the iron. Wipe the iron clean of solder, let the area cool and repeat.

3. Various desoldering devices are available to remove unwanted solder. The least expensive is a narrow strip of braided copper wire called a "desoldering wick". Position the wick over the solder bridge. Apply heat to the braid with a clean iron. When the wick soaks up the melted solder by capillary action, remove it. Repeat if necessary.

   Another device, the "desoldering pump", should be used only after you have mastered the art of soldering. Follow the instructions supplied with the device.

THE MOTHERBOARD

INTRODUCTION

The main printed circuit board (PCB), often referred to as the "motherboard" or the "6502 board", holds all of the electronic components of the computer. "Printed circuit" refers to any electrical circuit where the various lead wires are replaced by a thin layer of metal bonded to an insulating base material. A sheet of "glass epoxy" acts as the base. A layer of thin copper, the foil, is bonded to both sides of the base and then etched away to form "conductor lines" or "traces". "Through-plated holes" connect one side of the board to the other side. Sockets and electronic components are soldered to the foil. Electrical signals between components can now be exchanged along the traces. The board is treated to "resist scratch" as well as to "resist solder". Paint is then baked on and the board is finally "silk-screened" - i.e., a legend or component layout is clearly printed to show the correct location and orientation of each component.

PREPARATION

1. Keep the board free of grease, dirt, finger-prints and other contaminants. Handle it only by its edges. Do not accept a board that is warped or one with cracked or broken traces. The traces should be smooth and shiny.

2. Bending the board may crack or break the traces causing poor or no electrical conduction between components.

3. Protect the board by working on either a sheet of foam or a piece of clean cardboard about 10 to 15 cm larger than the motherboard itself.

4. Examine the silk-screened legend in the component side of the board. Study the component layout and note the position of each and every socket and electronic component. Compare your parts list with the component layout of the board.

   CAUTION ALL SOCKETS AND ELECTRONIC COMPONENTS ARE INSTALLED ON THE COMPONENT SIDE OF THE BOARD; ALL PINS AND WIRE LEADS ARE SOLDERED TO THE SOLDER SIDE.

5. Study Fig. 2-16 if you plan to assemble the Apple™ compatible (6502) circuit board.

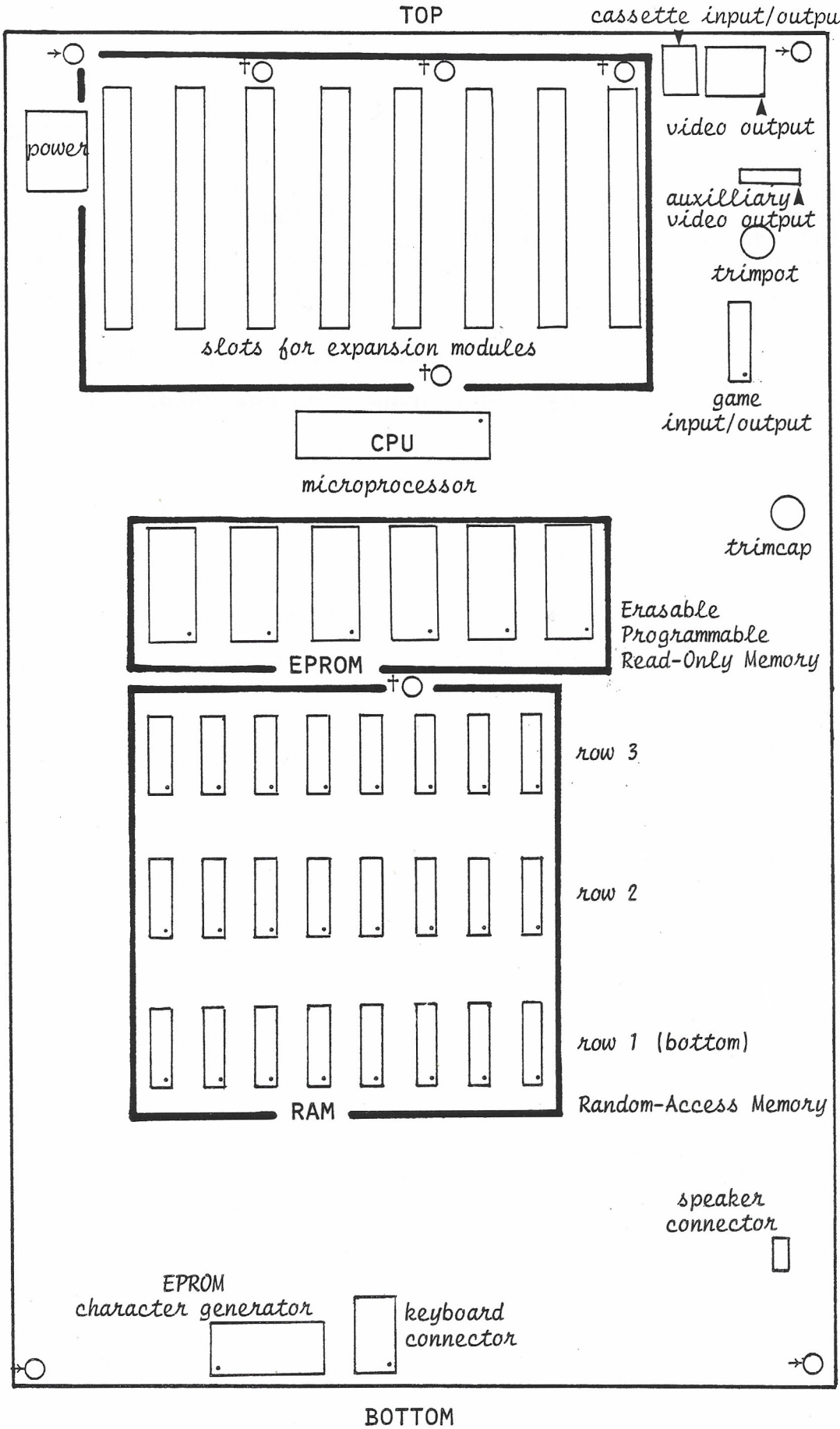


Fig. 2-16. THE MAIN CIRCUIT BOARD OF AN APPLE™ COMPATIBLE MICROCOMPUTER. The position of the four corner fasteners and the five inner spacers are shown by the symbols → and †, respectively. The dots represent the positions of pin number 1.

THE SEQUENCE

The following is a suggested guide for the installation of the various electronic components on the 6502 board. As a general rule, install the components that are shortest in height followed by the taller ones. This helps to keep the components flush against the board when soldering.

INSTALL COMPONENTS IN THIS ORDER

CHECK IN THE SPACE PROVIDED WHEN COMPLETED

_____ resistors

_____ diode

_____ coil

_____ SIP resistors

_____ smallest capacitors, then larger ones

_____ sockets

_____ transistors

_____ trimpot

_____ trimcaps

_____ crystal

_____ header pins (auxilliary video and speaker connectors)

_____ audio cassette jacks

_____ video jack

_____ power supply plug

_____ edge card connectors; install these only after the computer has been tested for correct operation

PRECAUTIONS

IN THIS GUIDE THE TERM "ON-BOARD LABEL" REFERS TO THE COMPONENT IDENTIFICATION WHICH IS SILK-SCREENED ON THE UPPER OR COMPONENT SIDE OF THE PRINTED CIRCUIT BOARD.

ALL ELECTRONIC COMPONENTS AND SOCKETS ARE INSTALLED ON THE COMPONENT (UPPER) SIDE OF THE PRINTED CIRCUIT BOARD. ALL SOCKET PINS AND WIRE LEADS ARE SOLDERED TO THE SOLDER (LOWER) SIDE OF THE BOARD.

ALL SILK-SCREENED LABELS ILLUSTRATED IN THIS GUIDE MAY NOT NECESSARILY BE PRESENT ON YOUR CIRCUIT BOARD.

ALL ELECTRONIC COMPONENTS AND SOCKETS SHOWN IN THE TEXT MAY NOT NECESSARILY BE REQUIRED IN THE CONSTRUCTION AND ASSEMBLY OF YOUR PARTICULAR MICROCOMPUTER.

CHECK THE POWER SUPPLY LEADS CAREFULLY. REVERSED POLARITY AND INCORRECT VOLTAGES WILL DESTROY INTEGRATED CIRCUITS AND DAMAGE ELECTRONIC COMPONENTS.

THE POWER MUST BE OFF WHEN SOLDERING, OR WHEN INSTALLING OR REMOVING INTEGRATED CIRCUITS AND COMPONENTS.

DON'T RUSH YOUR WORK. DO EACH SERIES OF STEPS CAREFULLY. UNDER NO CIRCUMSTANCES SHOULD YOU PANIC. THERE IS NO ERROR SO GREAT THAT IT CANNOT BE CORRECTED WITH CALM THOUGHT.

3.

SOME ELECTRONIC COMPONENTS

RESISTORS

Letter code: R

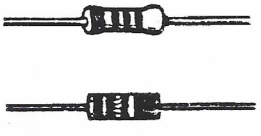
Schematic symbol:

variable

INTRODUCTION

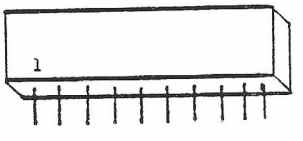
1. Resistors reduce the flow of electrical current while not stopping it completely. They act as voltage dividers to various semiconductors.

2. Resistors come in a variety of shapes, sizes and values. The 6502 board use the following types of resistors:



¼ watt resistors

potentiometer (trimpot)



SIP resistor

Fig. 3-1. THREE TYPES OF RESISTORS.

3. The numerical values for resistors are expressed in ohms and the symbol for the unit is Ω.

1 mega-ohm = 10^3 kilo-ohms = 10^6 ohms

1 MΩ = 10^3 kΩ = 10^6 Ω

1 MΩ = 1,000 kΩ = 1,000,000 Ω

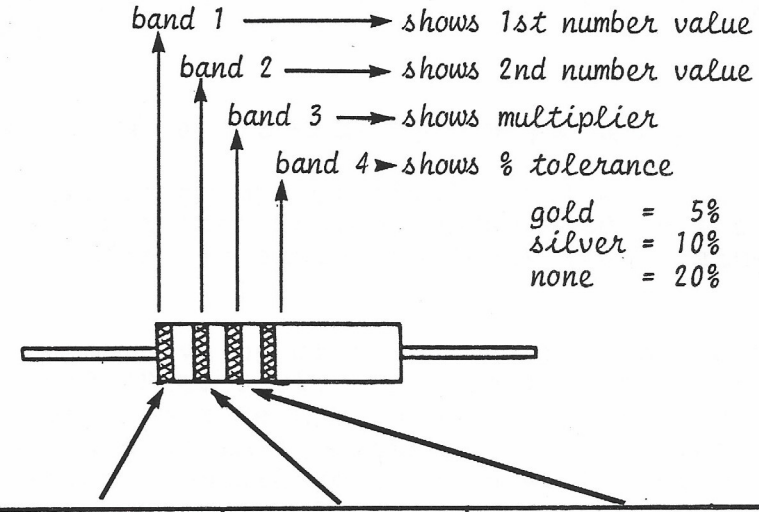
Examples: a) 4 kΩ = 4,000 Ω

b) 2.2 MΩ = 2,200,000 Ω

c) 6,000 Ω = 6.0 kΩ

4. The ohms value of resistors (as well as certain capacitors) is colour coded on its body. Each colour band represents a specific value. Table 3-1 shows resistor values by colour.

Table 3-1. Resistor colour code chart.


band 1 → shows 1st number value
band 2 → shows 2nd number value
band 3 → shows multiplier
band 4 → shows % tolerance
gold = 5%
silver = 10%
none = 20%

colour	1st digit	2nd digit	multiplier
black	0	0	1
brown	1	1	10
red	2	2	100
orange	3	3	1,000
yellow	4	4	10,000
green	5	5	100,000
blue	6	6	1,000,000
violet	7	7	10,000,000
gray	8	8	100,000,000
white	9	9	1,000,000,000
gold	-	-	0.1
silver	-	-	0.01

Examples: a) *yellow - violet - black refers to*
4 7 x1 = 47 Ω resistor
b) *brown - green - red refers to*
1 5 x100 = 1,500 Ω or 1.5 kΩ resistor

5. It's sometimes possible to substitute one resistor for another. Try to stay within the specified % tolerance of the resistor. Thus, a 1.8 kΩ or a 2.2 kΩ resistor can be used in place of a 2.0 kΩ unit if its tolerance is 10%.

   In timing circuits, however, where tolerances are specified, it's best to use the recommended value.

   A ½ watt resistor may be substituted for a ¼ watt resistor if space allows.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. Organize resistors in groups of similar values. Install all resistors so that their colour codes read in the same direction. This makes it easier to check their values later, if necessary.

2. The position and ohms value of each resistor should be clearly shown on the board (Fig. 3-2). On occasion, however, a bad production of boards may result in poorly silk-screened numerical values and decimal points. If you suspect an error or a deletion, compare your board with another, or refer the problem to the supplier.

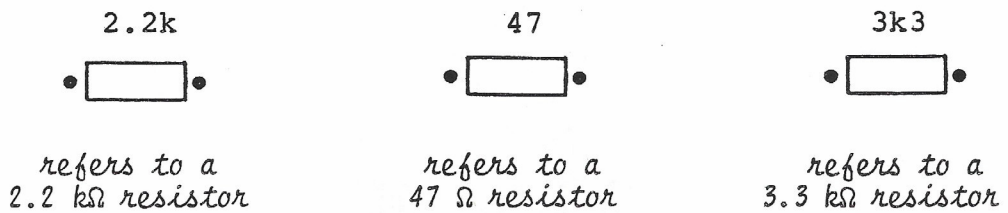


Fig. 3-2. ON-BOARD LABELS AND VALUES OF RESISTORS.

3. Use small needle-nosed pliers to bend the leads of resistors at right angles. Match the length of the lead to the distance between the two holes in the board (Fig. 3-3).

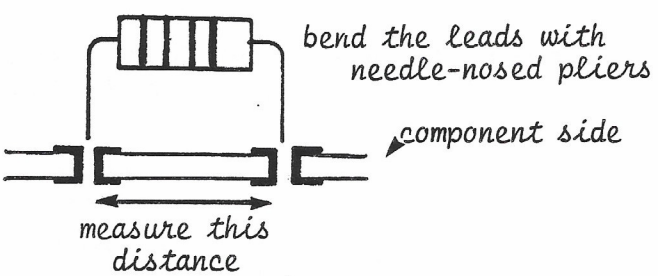


Fig 3-3. INSTALLING A RESISTOR.

4. Install the resistor through the component side of the board. Turn the board solder side up and gently push or pull the device flush against the board. Bend each lead slightly outward to secure it in place (Fig. 3-4). Overbending may result in the lead inadvertently touching an adjacent trace which could result in a short circuit.

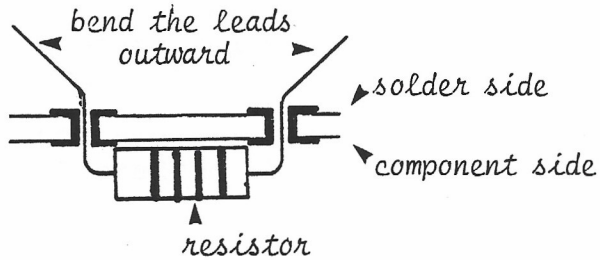


Fig. 3-4. SECURING THE RESISTOR IN PLACE BEFORE SOLDERING.

5. If a resistor is not lying flat against the board, adjust it by pushing up on the device with your finger while applying the soldering iron to the soldered connection. Refer to Fig. 3-5. The iron will melt the solder and the pressure should "pop" the resistor in place. Take care - it can get hot.

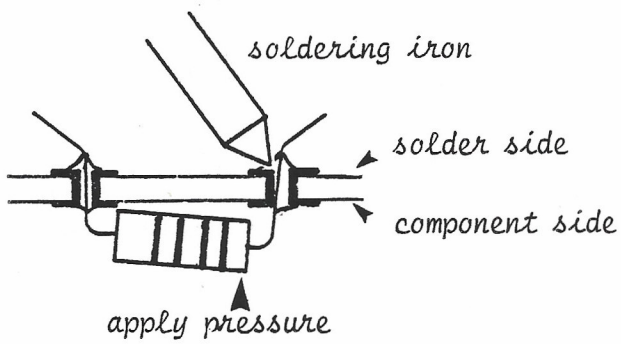


Fig. 3-5. ADJUSTING THE RESISTOR FLUSH AGAINST THE BOARD. OTHER COMPONENTS CAN BE ADJUSTED IN A SIMILAR MANNER.

6. Resistors are sometimes installed on end if space on the board is restricted (Fig.3-6).

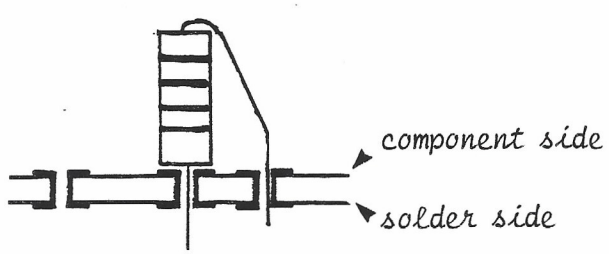


Fig. 3-6. INSTALLING A RESISTOR ON ITS END.

7. Install the remaining resistors.

8. You can save time by installing several resistors together and securing each one in place. All of these can be soldered at the same time.

9. CHECK AND RECHECK that the correct resistor is in the correct position. Turn the board solder side up and cut off excess lead lenghts as close to the board as possible.

Install the SIP RESISTORS and the TRIMPOT after the smaller components have been soldered to the board.

SINGLE-IN-LINE (SIP) RESISTORS

1. The ohms value of SIP resistors may be printed on the body of the component. The value can be determined using Table 3-2, Multiplier and Tolerance Chart for Capacitors. If you consider "152" as the number, then the first two digits indicate the number value (15); the third digit refers to the multiplier (100) or to the number of zeroes (2).

   Thus, 152 = 1500 Ω or 1.5 kΩ

2. Pin number 1 of SIP resistors may be identified by a bar, a number, or a dot. Pin 1 is common and must be positioned correctly in the circuit on the board.

3. Some 6502 boards call for an 8-pin SIP resistor, whereas others require a 9-pin device. As it may be necessary to purchase a 10-pin SIP resistor, then one or two of the pins must be removed. Use cutting pliers to cut off the pin(s) as close to the body of the device as possible (Fig. 3-7)

CAUTION PIN NUMBER 1 IS COMMON AND MUST NOT BE REMOVED.

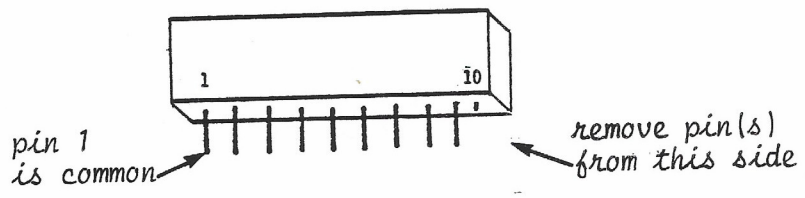


Fig. 3-7. PREPARING A SIP RESISTOR.

4. The silk-screened label and the position of pin 1 of SIP resistors is illustrated in Fig. 3-8. Match pin 1 of the SIP to pin 1 on the board and push the component through the holes. Solder the pins to the foil.

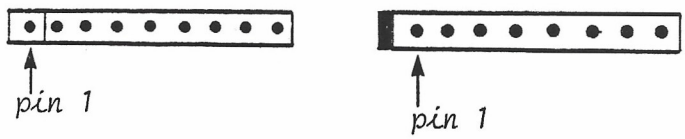


Fig. 3-8. SILK-SCREENED LABELS OF SIP RESISTORS. THE POSITION OF PIN NUMBER 1 IS IDENTIFIED BY EITHER A SOLID LINE OR A SQUARE.

TRIM POTENTIOMETER (VARIABLE RESISTOR or TRIMPOT)

1. The level of the video signal can be adjusted from zero to one volt peak-to-peak by a potentiometer. Setting the control to zero (full counter-clockwise) results in no picture; setting it to maximum (full clockwise) produces a dark and distorted picture. Make an initial adjustment of the trimpot by positioning the control with a narrow screwdriver to its centre position. A final adjustment should be made when the board is complete and running.

2. The on-board labels of the trimpot are shown in Fig. 3-9.

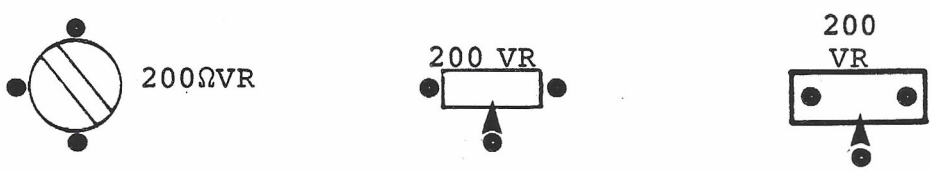


Fig. 3-9. TRIMPOT SILK-SCREENED ON THE BOARD.

3. Push the three pins of the trimpot through the holes in the board and solder them to the foil.

DIODE *Letter code:* D

Schematic symbol:

LED

INTRODUCTION

1. Diodes are electronic devices that allow current to flow in only one direction (forward bias). The anode (+ve) and the cathode (-ve) leads of diodes must be correctly positioned in the circuit.

2. The 6502 board requires one general-purpose, silicon, signal diode. It resembles a small ¼ watt resistor but has a glassy appearance.

3. Light emitting diodes (LED) may be required on other circuit boards such as the Z-80 soft card. The method of identifying the leads of LEDs is shown in Fig. 3-10.

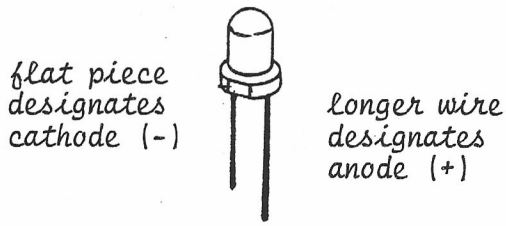


Fig. 3-10. IDENTIFYING THE POLARITY OF LEDs.
N.B. LEDs are not used on the 6502 board.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. Diodes are delicate and can be easily damaged by rough handling and excessive heat. Prepare the component as shown in Fig. 3-11. Secure one of its leads close to the body of the device with needle-nosed pliers and gently bend the lead down with your fingers. Repeat on the other side.

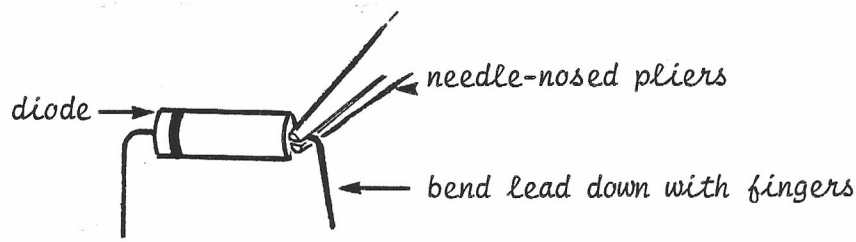


Fig. 3-11. PREPARING THE DIODE FOR THE 6502 BOARD.

2. Fig. 3-12 illustrates the correct method of installing the diode. The banded end must be positioned as shown.

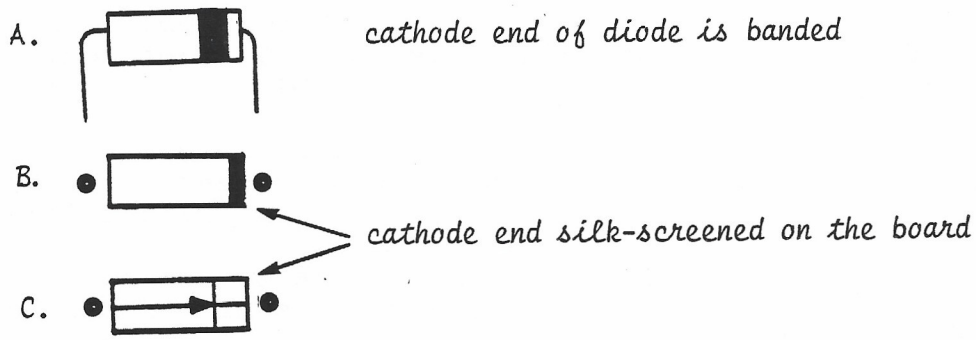


Fig. 3-12. A. DIODE; B. & C. ON-BOARD LABELS OF THE DIODE. THE DIODE MUST BE CORRECTLY POSITIONED ON THE BOARD.

3. Install the diode through the holes in the board and bend the leads slightly outward (Fig. 3-13). Keep the body of the device close to the board. Solder the leads to the foil and cut off excess lead lengths.

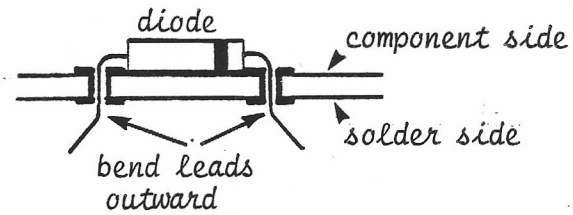


Fig. 3-13. INSTALLING THE DIODE.

INDUCTOR *Letter code:* L

Schematic symbol:

INTRODUCTION

1. The value of inductors (coils) is colour coded on the component. The value, in microhenries (µH), can be determined using Table 3-1. Resistor Colour Code Chart.

2. The 27 µH coil used on the 6502 board is part of the colour circuitry. It resembles a ½ watt resistor and is installed in a similar fashion.

3. Inductors are not polarized and may be installed with their leads positioned in any manner.

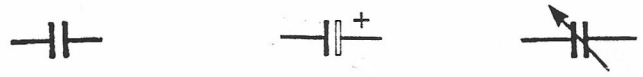
INSTALLATION *Clean the tip of the soldering iron frequently.*

1. Use needle-nosed pliers to bend the leads of the device to their correct length.

2. Install the component flat against the board and solder the leads to the foil. Cut off excess lead lengths close to the board (Fig. 3-14).

Fig. 3-14. A. SILK-SCREENED LABELS ON THE BOARD; B. INDUCTOR.

CAPACITORS *Letter code:* C

Schematic symbol: 

electrolytic *variable*

INTRODUCTION

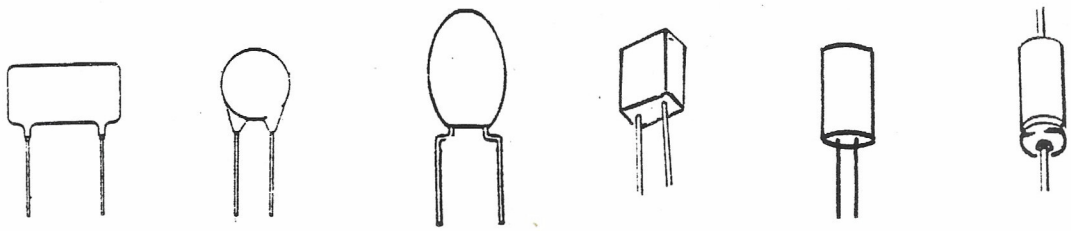
1. Capacitors are electronic components capable of storing electrical energy. Two values are assigned to capacitors: voltage rating and capacitance.

   a) Voltage rating, usually printed on the component, shows how much voltage can safely be used without damaging the capacitor. The rating must be higher than the highest expected voltage in the circuit.

   b) The unit for capacitance is the farad and its symbol is F.

1 farad	= 10^6 microfarads	= 10^{12} picofarads
1 F	= 10 μF	= 10^{12} pF
1 F	= 1,000,000 μF	= 1,000,000,000,000 pF

2. Fig. 3-15 shows variations in the packaging of capacitors.



a Mylar *b Ceramic disc* *c Tantalum* *d Military ceramic* *e Tubular (radial)* *f Tubular (axial)*

Fig. 3-15. SOME VARIETIES OF CAPACITORS. RADIAL CAPACITORS, a-e. AXIAL CAPACITOR, f.

NB. The term "radial" describes any electronic component where the component leads emerge from the same side. "Axial" components have their leads emerge from opposite ends, along the axis.

3. Capacitors are either electrolytic (polarized) or non-electrolytic (non-polarized)

   a) Electrolytic capacitors must be connected so that their positive (+ve) and negative (-ve) terminals or poles are correctly positioned in the circuit. Match the +ve end of the capacitor to the +ve label on the circuit board.

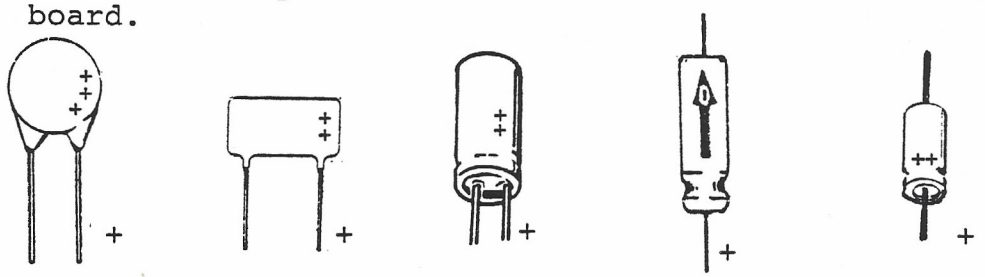


Fig. 3-16. IDENTIFYING POSITIVE LEADS OF CAPACITORS.

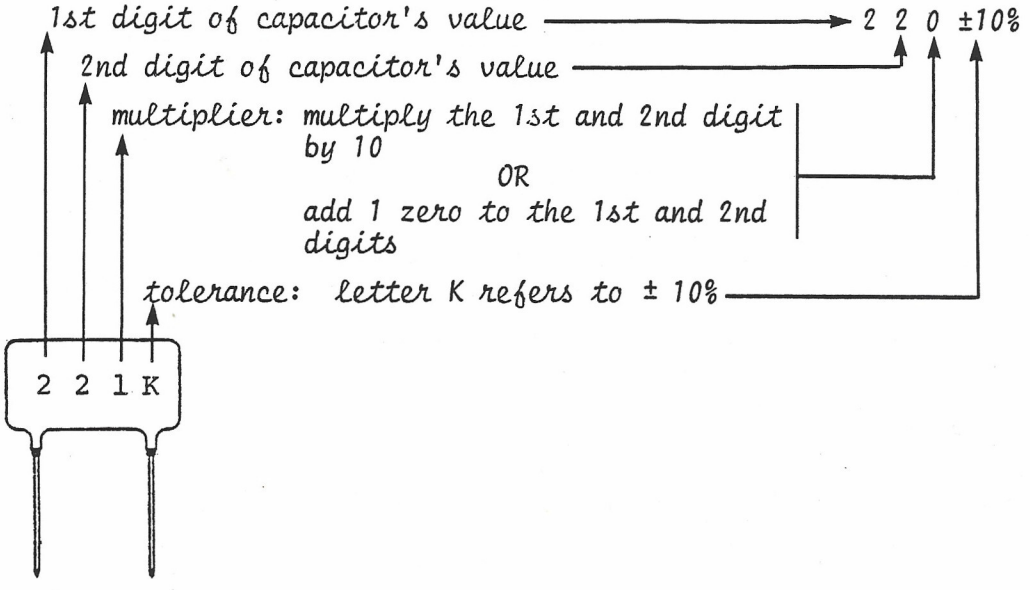
   b) Non-electrolytic capacitors have neither +ve nor -ve ends and may be installed in any manner. All capacitors used on the 6502 board are of this type.

4. The numerical value of a capacitor is usually printed on the body of the device. Table 3-2 and the accompanying examples illustrate how this value is derived.

Table 3-2. Multiplier and Tolerance Chart for Capacitors.

MULTIPLIER		TOLERANCE		
for the number:	multiply by:	10 pF or less	letter	over 10 pF
0	1	± 0.1 pF	B	-
1	10	± 0.25 pF	C	-
2	100	± 0.5 pF	D	-
3	1,000	± 1.0 pF	F	± 1%
4	10,000	± 2.0 pF	G	± 2%
5	100,000	-	H	± 3%
-	-	-	J	± 5%
8	0.01	-	K	± 10%
9	0.1	-	M	± 20%

Example: 221K *printed on the capacitor refers to a value of* 22 X 10 = 220 pF, *with a tolerance of* ± 10%


1st digit of capacitor's value
2 2 0 ±10%
2nd digit of capacitor's value
multiplier: multiply the 1st and 2nd digit by 10
OR
add 1 zero to the 1st and 2nd digits
tolerance: letter K refers to ± 10%
2 2 1 K

Another example: 104M *printed on a capacitor means a value of* 10 X 10,000 = 100,000 pF *or* 0.1 µF *with a tolerance of* ± 20%.

Larger capacitors have their values and units printed directly on the device.

Certain capacitors are colour coded and use the same code as that for resistors. Refer to Table 3-1, Resistor Colour Code Chart.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. Organize the capacitors in groups of similar values. Position capacitors so that their marked values can easily be read after installation. This makes for easier troubleshooting later, if necessary.

2. The location and values of capacitors may be shown on the board in the following ways:

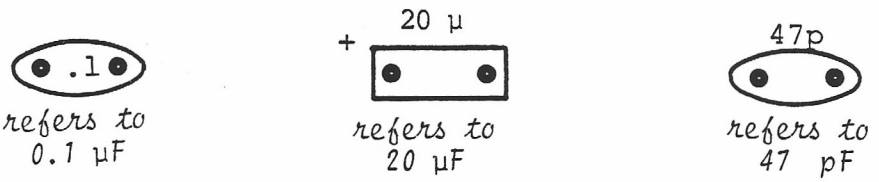
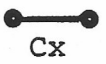


Fig. 3-17. ON-BOARD LABELS OF CAPACITORS AND THEIR VALUES.

Some circuit boards label the capacitor where x refers to its value. 

Other boards have a legend identifying the position of capacitors rather than silk-screening the same value repeatedly.

For example, the legend " = .1" tells you to install a 0.1 µF capacitor each time you see the symbol .

3. Prepare one capacitor by carefully bending its leads so that the device will fit into the board. Install the capacitor through the component side of the board and secure it in place by bending its leads slightly outward. Keep the body of the capacitor as close to the board as possible without damaging it (Fig. 3-18).

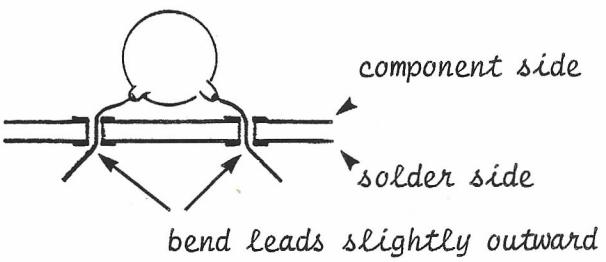


Fig. 3-18. SECURING THE CAPACITOR.

4. Turn the board solder side up and solder the leads to the foil. Take care! Too much heat may damage the capacitor and the board. Trim excess lead lengths as close to the board as possible with diagonal cutters.

5. Install the rest of the capacitors in a similar manner.

6. You can work faster and more efficiently by installing several capacitors together, securing each in place, and then soldering them all at one time. Before soldering, however, check for correct values.

VARIABLE CAPACITORS (TRIMCAP, or TRIMMER)

1. Install the larger variable capacitors only after the smaller components have been soldered in place.

2. The trimcap labels on the board are shown in Fig. 3-19.

Fig. 3-19. ON-BOARD LABELS OF A TRIMCAP.

3. Install the trimcap so that the common terminals of the device are aligned with the common solder pads on the board. Ease the pins of the component through the holes in the board and solder the three pins to the foil.

4. Some motherboards have TWO locations for the SAME trimcap. Select the one which is readily accessible for adjustment after the motherboard has been installed in the case.

5. The trimcap(s) can be adjusted for colour and hue when the computer is running and a colour test pattern is displayed on the TV screen.

4.

THE SOCKETS

INTRODUCTION

1. Dual-in-line package (DIP) sockets contain two parallel rows of pins that are permanently soldered to the PCB. Integrated circuits (ICs) can be inserted into the sockets or removed for replacement when required.

2. The 6502 board requires solder tail DIP/IC sockets of which three are considered here.

   a) Tin inlay contacts: are the least expensive and used where general-purpose sockets are required.

   b) Gold inlay contacts: are more expensive, of better quality and give better IC pin contact. Recommended where ICs are removed and inserted occasionally (RAMs and MPU).

   c) Machine contact (gold on tin): often referred to as "augut gold", are the most expensive, costing several times more than tin inlay. They form a superior contact with pins of ICs and DIP connectors. They should be considered for EPROM ICs, as well as keyboard and joystick connectors.

3. Edge connectors: Use the best quality gold inlay here as peripheral cards (such as 16 K RAM card and controller card) will probably be installed and removed often. Install the edge connectors only after your computer is checked out and running properly.

4. Pins of old sockets may appear dull-gray and pitted as a result of oxidation. Return these to your dealer and have then replaced. They will not take the solder.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. The location of sockets on the board can be identified in any one of the following ways:

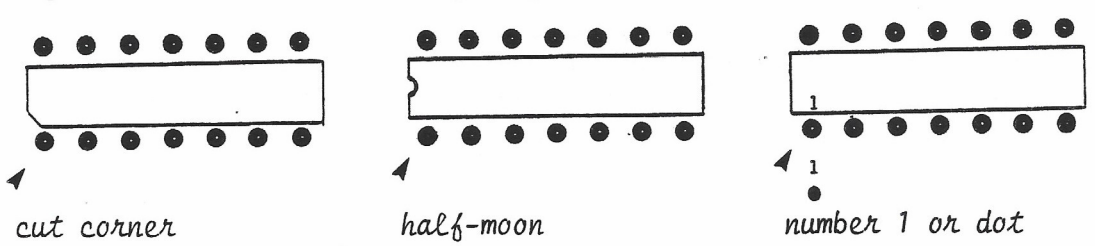
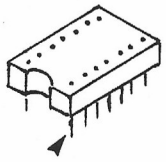
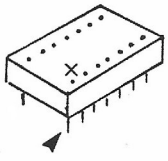


Fig. 4-1. ON-BOARD LABELS OF SOCKETS. ARROWS INDICATE THE POSITION OF PIN NUMBER 1.

2. Pin number 1 of SOCKETS can be identified in one of several ways (Fig. 4-2). Install sockets so that pin 1 of each socket mates with pin 1 on the board.



a half-moon or rectangular notch



a dot or triangular indentation or number "1" at ×

Fog. 4-2. TOP VIEW OF SOCKETS. ARROWS INDICATE THE POSITION OF PIN NUMBER 1.

3. The order of installing sockets is arbitrary. Some possible combinations are to:

   a) install the smallest, thinnest sockets first, followed by the thicker deeper ones;

   b) install sockets in rows, starting at co-ordinate A, 1 to 13; B, 1 to 13; C, 1 to 13; etc.;

   c) install all 8-pin sockets first; then all 14-pin sockets; etc.

CAUTION INSTALL THE EIGHT EDGE CONNECTORS ONLY AFTER YOUR COMPUTER IS FINISHED AND KNOWN TO BE OPERATING CORRECTLY.

4. Insert the pins of one socket through the holes of the board. Do not force them. Use the tip of a nail file or other fine-tipped tool to gently play a stubborn pin into its opening. Take care - don't scratch the board!

5. Hold the socket in place with your finger so that the socket doesn't fall out and turn the board solder side up. Avoid future problems!

CAUTION THIS IS ONE OF THE MAIN PROBLEM AREAS.

Check that ALL the pins of the socket have passed through ALL the holes in the board. This can readily be done by touching each pin with a nail file.

6. Gently bend the two opposite corner pins slightly outward to secure the socket into position. Some sockets are made so that they remain secured once installed. Solder ONE of the corner pins to the foil. Next solder the OPPOSITE corner pin to the foil (Fig. 4-3).

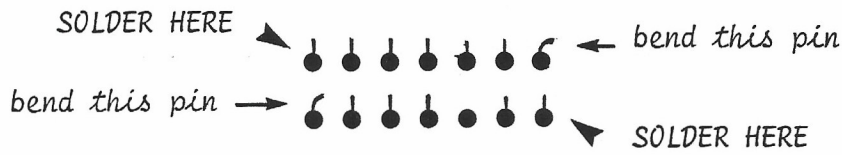


Fig. 4-3. SOLDER ONLY THE TWO CORNER PINS. Note a missing pin.

7. Recheck that ALL the pins have passed through their correct openings. A major problem is folded-under pins, i.e., bent pins lodged between the socket and the board (Fig. 4-3).

8. Straighten any socket that isn't tight against the board. Refer to Fig. 3-5, Adjusting the Resistor Flush Against the Board. Push up on the socket with your finger while applying heat to the soldered connection. The iron will melt the solder and the pressure of your finger will "snap" the socket into place.

9. Install the remaining sockets in the manner previously described. Solder only the two OPPOSITE corner pins at this time. It's easier to remove and correctly replace a socket at this time rather than later when all the pins have been soldered to the foil.

CHECK AND RECHECK

a) that pin 1 of each socket is properly orientated on the board

b) that each socket is installed in the correct position, i.e., a 14-pin socket should not be in a 16-pin socket opening

c) that all socket pins are inserted in their openings, i.e., no folded-under pins

d) that each socket is flat against the board.

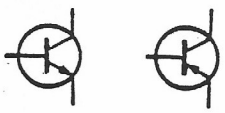
10. Do not attempt to remove a socket if it has been installed with pin 1 positioned incorrectly (socket turned through 180°). Instead, apply a very small dab of coloured nail polish to the corner of the socket to identify pin number 1.

11. Complete the soldering. Solder the rest of the pins to the foil. This can be done quickly by working down one row of pins. Turn the board through 180° and solder the other row.

5.

MORE ELECTRONIC COMPONENTS

TRANSISTORS *Letter code:* Q

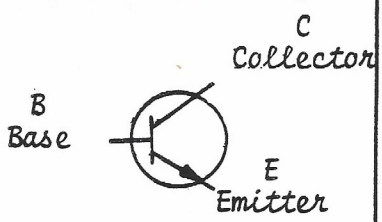
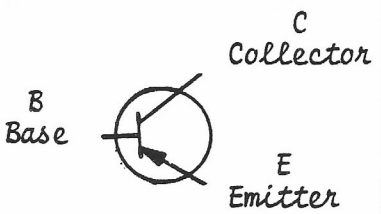
Schematic symbol: 

INTRODUCTION

1. Transistors, electronic devices that are used as simple amplifiers and switches, have virtually replaced glass radio tubes used in the past. The introduction of the transistor to electronics and the development of the silicon circuit on a chip are two factors responsible for the rapid growth of the microcomputer. The transistors used on the 6502 board are low-power, high-frequency, small-signal/switching devices.

2. Two types of transistors are found in modern circuits: bipolar transistors and Field Effect Transistors (FET). The 6502 board uses only bipolar devices. Bipolar (NPN and PNP) transistors are essentially made of n-type and p-type slabs of semiconductors. Think of the NPN device as a three-layered structure consisting of a p-type slab sandwiched between two n-type slabs: the PNP device is reversed. Refer to Table 5-1 for a brief comparison of bipolar transistors.

Table 5-1. Comparison of Bipolar Transistors.

	NPN	PNP
schematic symbols with labels		
polarity (arrows indicate direction of current flow)	current flows from base to emitter	current flows from emitter to base
voltage	applied to base (p-type) must be +ve with respect to emitter	applied to base (n-type) must be -ve with respect to emitter

3. Fig. 5-1 illustrates variations in packaging of transistors.

Fig. 5-1. THE THREE TRANSISTOR LEADS MUST BE CORRECTLY POSITIONED ON THE BOARD.

4. Handle transistors with care. Protect them from mechanical injury. Use minimum heat when soldering.

5. Transistors may be destroyed if their three leads are incorrectly positioned in the circuit. Identifying the three E-B-C wire leads, however, presents a problem: the body of the device may or may not be labelled; the circuit board may or may not be correctly silk-screened; different manufacturers arrange the E-B-C leads differently.

CAUTION NO GENERAL RULE IS GIVEN IN THIS GUIDE REGARDING THE IDENTITY OF THE THREE LEADS OR THE POSITION OF THESE LEADS ON THE BOARD. IF IN DOUBT, CONSULT YOUR DEALER.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. The following sketches (Fig. 5-2) represent transistors silk-screened on the circuit board. The letters may be shown in either upper case or lower case.

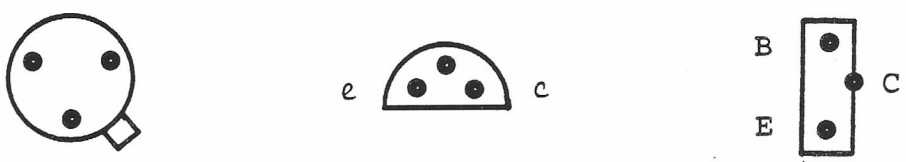


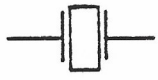
Fig. 5-2. TRANSISTORS SILK-SCREENED ON THE CIRCUIT BOARD.

2. Gently bend the three transistor leads to match the distance between the holes in the board. Insert the E-B-C leads of the transistor into their corresponding E-B-C holes. Position the transistor approximately 0.5 cm above the board as shown in Fig. 5-3.

Fig. 5-3. INSTALLING THE TRANSISTOR.

3. Turn the board solder side up and bend the leads slightly outward to secure the device in place. Solder the leads to the traces. Trim excess leads close to the board.

CRYSTAL *Letter code:* Y

Schematic symbol: 

INTRODUCTION

1. The quartz crystal that is used in the 6502 circuitry generates a frequency of 14.318180 megahertz (MHz) which means that it runs at 14,318,180 cycles per second. This frequency is scaled down by counters to synchronize the operation of the computer.

2. The crystal (shown in Fig. 5-4, A) is not polarized and may be installed with leads positioned in any manner. The oscillating frequency is printed on the device.

3. Protect the crystal from mechanical shock and excessive heat.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. The on-board labels of the crystal are shown in Fig. 5-4, B.

A. Crystal *B. Silk-screened Labels*

Fig. 5-4. A. QUARTZ CRYSTAL; B. ON-BOARD LABELS.

2. Install the device tight against the component side of the board and solder the two leads to the solder side. Use minimum heat. Trim off excess leads close to the board.

CAUTION AVOID BENDING OR MOVING THE CRYSTAL AFTER INSTALLATION. THE CRYSTAL STANDS HIGHER THAN MOST OF THE OTHER COMPONENTS AND THE LEADS ARE EASILY BROKEN WITH EXCESS MOVEMENT.

6.

THE CONNECTORS

VIDEO CONNECTOR

A. VIDEO OUTPUT CONNECTOR

1. The video phono jack, installed at the right-hand corner of the 6502 board (Fig. 2-16), allows you to hook up your computer to an external TV monitor.

2. Examine the standard RCA female phono jack. The three outside pins of the sleeve are common and are connected to the board's common ground. The centre pin, separated from the sleeve by insulation, is connected to the video output signal via the 200 ohm trimpot.

3. The pins of the jack may not quite fit the holes on some of the boards. If necessary, gently bend the pins with needle-nosed pliers. Install the jack through the holes and solder the pins to the foil.

4. Purchase a coaxial cable complete with appropriate phono plugs from your hi-fi dealer.

B. AUXILLIARY VIDEO OUTPUT CONNECTOR

1. This connector is installed just below the video phono jack (Fig. 2-16).

2. Install a pin header connector through the holes in the board and solder the pins to the foil (Fig. 6-1). Rigid wire or discarded resistor wire leads may be used if a pin header is not available.

3. The pin header may come as a 10-pin strip. If so, use a knife or other tool to cut or snap the strip into one 5-pin strip and one 3-pin strip (for the speaker connector). Some 6502 boards require a 4-pin header (Fig. 6-1).

A. 5-pin header B. on-board labels

Fig. 6-1. INSTALLING THE AUXILLIARY VIDEO CONNECTOR.

C. RF MODULATOR

1. The auxilliary video connector allows the computer to be hooked up to a home television set via an RF modulator. The modulator takes the composite video output information from the computer, converts it, and then passes it to the TV tuner and associated circuitry so that the picture can be displayed on the screen.

2. The modulator may be connected in one of three ways. Each lead must be connected to the correct pin on the board.

   a) Secure each one of the leads of the modulator to a matching female plug connector. Push the connector over the 5-pin header on the board (Fig. 6-2, A).

   b) Use this method if a female plug connector is not available. Solder small female socket pins to the end of each lead of the modulator. Push the sockets down over the correct pins of the header pin on the board (Fig. 6-2, B).

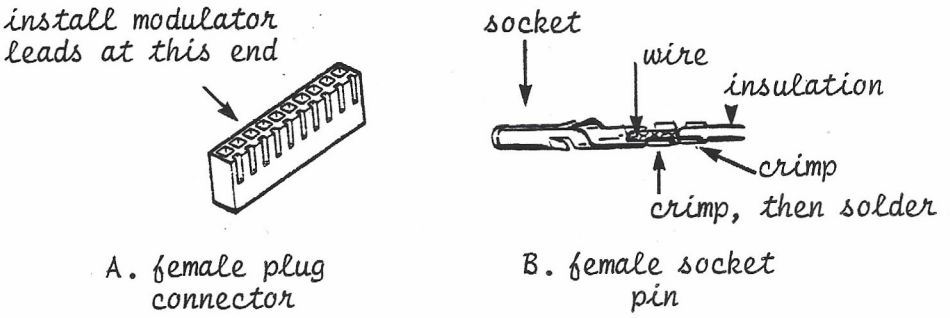


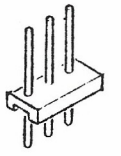
Fig. 6-2. PREPARING THE RF MODULATOR LEADS.

N.B. Modulators are usually interfaced to the computer via three leads: ground, video, and +12 v DC.

   c) Some modulators may be purchased complete with plug and need no preparation.

SPEAKER CONNECTOR

1. Prepare a pin header connector as illustrated in the previous section (auxilliary video connector). Install the 3-pin header through the holes in the board and solder the pins to the foil (Fig. 6-3).



3-pin header
install shorter pins into the board

on-board label

Fig. 6-3. INSTALLING THE 3-PIN HEADER.
N.B. Only two speaker wires are used.

2. Prepare two speaker wires, each about 50-100 cm in length. Remove approximately 8-10 mm of insulation from each end and twist the stranded wires together with your fingers.

3. Push the lead of one wire through the lug at the back of the speaker and twist it into place. Solder the wire to the lug as shown in Fig. 6-4.

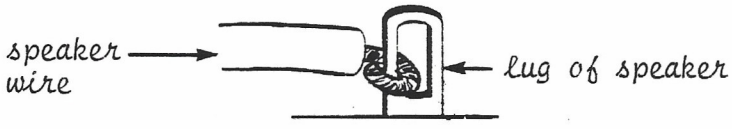


Fig. 6-4. CONNECTING THE SPEAKER WIRE.

4. Repeat the preceding (step 3) for the other speaker wire. The other ends of the speaker wires are connected to the 3-pin header in the same way as the RF modulator. Refer to it.

CASSETTE CONNECTORS

Two female printed board mount phone jacks, an input and an output, are required to connect the 6502 board to an external cassette tape recorder.

a) The input jack connects to the earphone or monitor output jack on the recorder. Information stored on the audio tape is transferred into the computer.

b) The output jack connects to the microphone input jack on the tape recorder. It transfers information out from the computer to the cassette to be stored on the audio tape.

INSTALLATION

1. Refer to Fig. 2-16 for the location of the "in" and "out" positions of the cassette jacks.

2. The on-board label of the jacks is shown in Fig. 6-5.

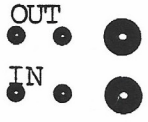


Fig. 6-5. CASSETTE JACKS SILK-SCREENED ON THE BOARD.

3. Install the two female jacks tight against the component side of the board and solder the pins to the foil (Fig. 6-6).

A. B.

Fig. 6-6. A. MALE PHONE PLUG; B. FEMALE PHONE JACK.

4. The cassette jacks on the computer may require subminiature phone plugs, whereas the cassette may need larger, miniature plugs. Check both the board and the cassette for the correct sizes. The cables, complete with connectors can either be purchased at your local hi-fi dealer or bought separately and assembled at home.

KEYBOARD AND GAME INPUT/OUTPUT CONNECTORS

The typewriter-style keyboard and the joystick are connected to sockets (see Fig. 2-16) on the 6502 board by means of flat ribbon cable assemblies with 16-pin DIP connectors.

EDGE CONNECTORS *Clean the tip of the soldering iron frequently.*

The following is a partial list of available bare PCBs (cards) that can be assembled by the hobbyist and interfaced with the 6502 board: controller, 16 K RAM, Z-80, EPROM programmer, RS-232 interface, Centronics parallel, 80 character.

INSTALLATION *Clean the tip of the soldering iron frequently.*

1. Install the eight 50-pin edge connectors only after you are sure that the computer is operating correctly. Your board will work fine without them.

   CAUTION THIS IS ANOTHER PROBLEM AREA

   The edge connectors require 400 (8 x 50) solder joints! It's easier to troubleshoot the rest of the board, if necessary, for solder bridges, folded-under pins, etc., without the edge connectors complicating things for you.

2. Switch off the power to the computer when soldering. Install the pins of ONE edge connector through the holes, push it tight against the board, and solder the pins to the foil. Power the computer up and determine if it is operating correctly. If it is, then proceed to the next connector.

3. Repeat step 2 for each one of the other connectors.

POWER SUPPLY

INTRODUCTION

Several varieties of switching power supply units are available. Some are open frame and lack an external case. Others are enclosed in a metal case, have the same dimensions as the real thing (approximately 9 cm x 24 cm x 4 cm) and will fit into a look-a-like case nicely. Purchase the best power supply available; one that meets or exceeds the specifications of the original, and has the capacity to run two disc drives and plenty of peripherals.

The DC output specifications of the power supply used by this author are:

+5v, 5A; -5v, 0.5A; +12v, 2.5A; -12v, 0.5A

The specifications of the original are:

+5v, 2.5A; -5v, 0.25A; +12v, 1.5A; -12v, 0.25A

CAUTION PURCHASE A POWER SUPPLY THAT HAS BEEN APPROVED FOR USE IN YOUR AREA. LOOK FOR A CANADIAN STANDARDS ASSOCIATION (CSA) OR HYDRO SPECIAL INSPECTION LABEL ON THE UNIT.

PREPARING THE POWER SUPPLY CABLE

CAUTION DIFFERENT POWER SUPPLIES HAVE DIFFERENT COLOURED WIRE LEADS. THESE LEADS MUST BE CORRECTLY INSTALLED. REVERSING THE POLARITIES OR THE VOLTAGES WILL DESTROY INTEGRATED CIRCUITS.

1. Identify the coloured wire leads using the colour code supplied with your particular unit. The code is normally stamped on the outside of the metal case. If not, remove the four screws holding the case to the body, lift the cover off, and locate the code. Attach a piece of masking tape to each one of the FIVE leads (Fig. 6-7). Label each lead: GND; +12; -12; +5; -5.

Fig. 6-7. LABELLING EACH OF THE FIVE LEADS.

N.B. If two of the wires have the same colour, tape them together.

2. Prepare ONE of the leads in the following manner:
   a) Use wire strippers to remove about 5 mm of insulation from the end of one lead.
   b) Twist the fine strands of wire together and melt just enough solder to the strands to keep them from separating.
   c) First crimp and them solder the prepared lead to an appropriate female socket (Fig. 6-8). Then crimp the tabs over the insulation to secure the lead in place.

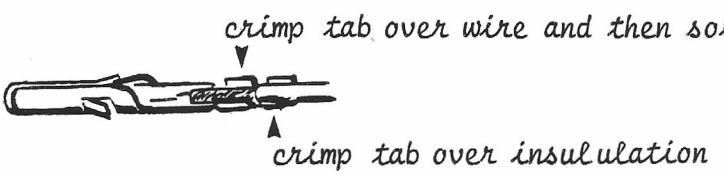


Fig. 6-8. PREPARING A FEMALE SOCKET PIN.

3. Prepare the other FOUR leads in a similar manner. If two of the leads have the same colour, solder them together.

CAUTION DO NOT PUSH THE PREPARED LEADS INTO THE POWER PLUG AT THIS TIME.

PREPARING THE POWER PLUG

1. Carefully examine the male and female power plugs. Note that one of the plugs (female) can be installed in ONLY ONE WAY! This ensures that the correct voltages will be supplied to the computer circuitry. Try pushing the female plug into the other. You may have to press the side tabs together to install and remove it.

2. The power plug may be silk-screened on the board as shown in Fig. 6-9.

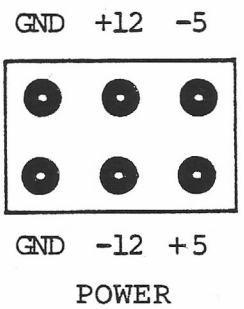


Fig. 6-9. ON-BOARD LABEL OF THE POWER PLUG.

3. Install the male plug flush against the component side of the board and solder the six pins to the foil.

4. Connect the female power plug to the male plug on the board. DO NOT REMOVE IT!

INSTALLING THE POWER SUPPLY LEADS TO THE PLUG

CAUTION THE FEMALE PLUG MUST BE CONNECTED TO THE MALE PLUG ON THE BOARD BEFORE INSERTING THE FIVE POWER SUPPLY LEADS.

The power supply leads are difficult to remove once installed. Install them correctly on your first attempt. Check off each step on the following sketch after completing it (Fig. 6-10).

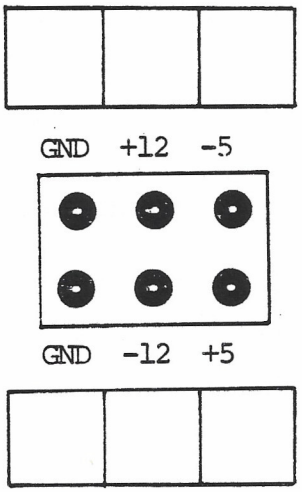


Fig. 6-10. WHEN COMPLETED, CHECK OFF EACH STEP IN THE BOXES PROVIDED.

1. Identify the power supply labelled GND and push its socket through any one of the two openings labelled "GND".
2. Identify the + 12 v lead of the power supply and push it through the "+12" opening of the plug.
3. Repeat for the -5 v lead.
4. Repeat for the -12 v lead.
5. Repeat for the +5 v lead.

7.

CHECK IT OUT

VISUAL CHECK

Before applying power, thoroughly check the completed motherboard.

1. Carefully inspect the solder side for

   a) unsoldered connections

   b) poorly soldered connections

   c) solder bridges between adjacent traces

   d) excessively long leads from resistors, capacitors, etc. that may cause short circuits.

2. Visually inspect the component side for

   a) proper installation of all sockets

   b) solder bridges between pins under sockets or between pins and traces

   c) correct installation of resistors and capacitors

   d) correct position of the positive marked leads of capacitors

   e) correct position of the banded end of the diode

   f) correct transistors in place with each lead positioned properly.

3. Compare your completed board to another or have a friend check it over for you.

8.

THE INTEGRATED CIRCUITS

INTRODUCTION

1. The most common types of integrated circuits (ICs) are available in dual-in-line packages (DIPs) and are embedded in either plastic or ceramic.

2. Handle ICs with care.

   a) Excessive voltage, reversed polarity, short ciruits, etc., can quickly destroy an IC.

   b) Protect them from mechanical injury.

   c) Keep EPROMs away from direct sunlight. Ultraviolet (UV) radiation of sunlight may partially erase some of the information programmed in an EPROM. Protect them by applying a non-transparent piece of tape or label over the transparent window.

   d) CPU, EPROM and RAM integrated circuits are MOS devices, are sensitive to static electricity, and require special handling. Store them only in their original shipping tubes or with their pins embedded in special conductive foam.

3. The pins of DIP/ICs are numbered in a counter-clockwise fashion when viewed from the top (Fig. 8-1).

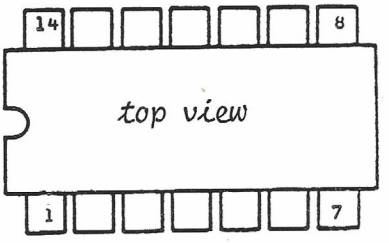


Fig. 8-1. TOP VIEW OF A DIP/IC SHOWING PIN NUMBERS.

INSTALLATION

CAUTION DO NOT INSTALL THE ICS AT THIS TIME. REFER TO SECTION 9 "POWER IT UP"

1. ICs must be correctly positioned in the circuit. Reversed polarity and voltage will damage them. Pin number 1 of an IC is identified by a label and is then matched with pin 1 of the socket on the board. The identifying label of ICs can be recognized in one of several ways (Fig. 8-2).

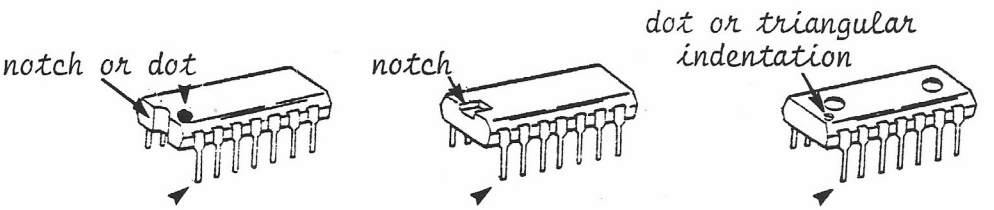


Fig. 8-2. TOP VIEW OF ICs. THE ARROWS IDENTIFY PIN NUMBER 1.

CAUTION THE POWER TO THE COMPUTER MUST BE OFF WHEN INSTALLING OR REMOVING ICS.

2. New ICs may have their pins set too far apart to comfortably fit the socket. If so, carefully bend the two rows of pins slightly inboard with needle-nosed pliers.

3. Install the correct IC into the correct socket! Refer to Fig. 4-2 for the correct socket identification. Match pin 1 of the IC to pin 1 of the socket. Before applying downward pressure, make certain that the pins of the IC are properly aligned with the socket holes. Carefully push the IC into its socket by applying pressure at various points along its length. Rock the IC into position. Protect the board. Undue pressure may bend the board excessively and may crack or break the traces.

CAUTION CHECK FOR BENT PINS. FOLDED UNDER PINS ARE ONE OF THE MAJOR CAUSES OF NON-FUNCTION BOARDS.

REMOVING INTEGRATED CIRCUITS

1. Refer to Fig. 8-3. Use a DIP/IC extractor to remove ICs. Grasp the IC at each end with the extractor. Gently rock the IC back and forth as you apply upward pressure. Pull the IC straight up to prevent the end pins from bending, weakening, and even breaking off. If an extractor is not available, use the blade of a narrow screwdriver, or small penknife. Insert the blade between the IC and the socket and gently rock it back and forth. Repeat on the other side. Pull the IC straight up.

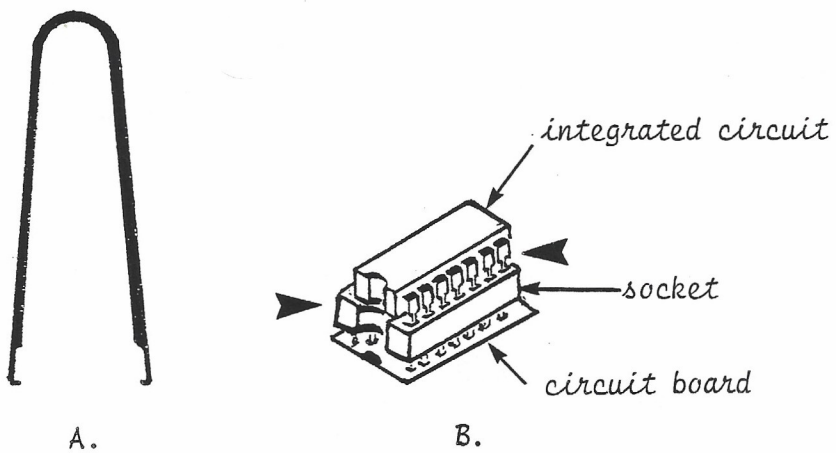


Fig. 8-3. A. DIP/IC EXTRACTOR; B. INSERT EXTRACTOR OR SCREWDRIVER BETWEEN THE IC AND THE SOCKET (between ➤ and ◀).

9.

POWER IT UP

CAUTION THE POWER MUST BE OFF WHEN INSTALLING OR REMOVING INTEGRATED CIRCUITS

1. Place the completed board on a non-metallic surface such as a sheet of cardboard or foam.
2. Turn the power supply switch off and disconnect the cord from the wall socket.
3. Connect the power supply plug (previously prepared) to the socket on the board.
4. Hook up the speaker.
5. Connect the computer to a TV monitor via the RCA phono jack or a TV receiver via an RF modulator.

CAUTION PIN 1 OF INTEGRATED CIRCUITS MUST BE MATED TO PIN 1 OF SOCKETS ON THE BOARD.

6. Refer to Fig. 2-16 and install the ICs in the following order:
   a) plug all ICs except the EPROMs and the RAMs into their correct sockets
   b) plug the six EPROMs into their respective sockets and the character generator EPROM into its socket
   c) plug only eight RAM ICs (16 K of RAM memory) into row 1 (bottom row) of RAM sockets.

N.B. Each row of RAM must hold the same kind of RAM.

CAUTION INSPECT ALL ICS FOR FOLDED-UNDER PINS AND POSITION ERRORS

CAUTION CHECK THAT THE CORRECT IC IS IN THE CORRECT SOCKET

7. Turn on the monitor or TV receiver and let it warm up.

8. Connect the power supply cord to a wall socket and turn the power switch on.

9. If a "bell" sounds and the screen displays a title and a flashing cursor then congratulations are in order (Fig. 9-1).

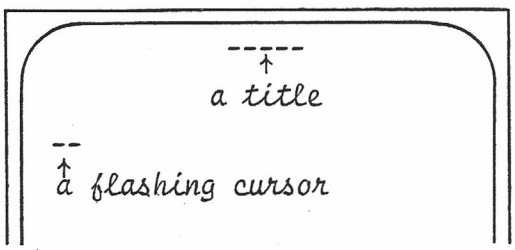


Fig. 9-1. CONGRATULATIONS!

10. Turn the power to the computer off and install the next eight RAM (total, 32 K of RAM) into the second row (middle row) of RAM sockets. Turn the computer on and check for correct operation.

11. Turn the computer off and install the next eight Ram (total, 48 K of RAM) into the third (top) row. Turn the computer on and again check for correct operation.

10.

FINAL ASSEMBLY

DISMANTLING THE CASE

1. Purchase a copy of an AP II case complete with keyboard and associated hardware.

2. Work on a large piece of cardboard to prevent damage to the case, completed board and your work area.

3. Use an appropriate screwdriver to remove the screws and rubber feet from the metal floor of the case. Store them in a safe place.

INSTALLING THE POWER SUPPLY

Position the power supply on the floor of the case so that the switch is at the back. Secure the unit to the floor with the appropriate screws. These may be metric; use the correct size.

INSTALLING THE MOTHERBOARD TO THE FLOOR PAN OF THE CASE

Spacers or supports between the motherboard and the floor are required to allow air to circulate and thus prevent heat build up, and to prevent short circuits between the circuit board and the metal floor. Furthermore, spacers give the needed support when pushing peripheral cards into edge connectors. Refer to Fig. 2-16 for the location of the spacers.

Use the following method if your case did not come with the necessary installation hardware:

a) Insert five ¼ inch plastic spacers (Fig. 10-1) through the botton of the board at positions marked † on Fig. 2-16. Some 6502 boards may not have all the holes illustrated.

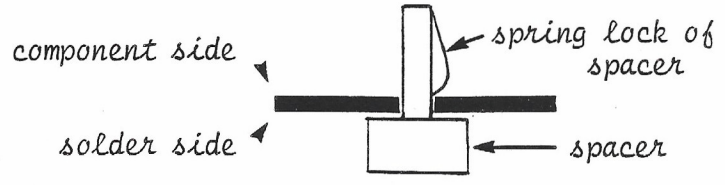
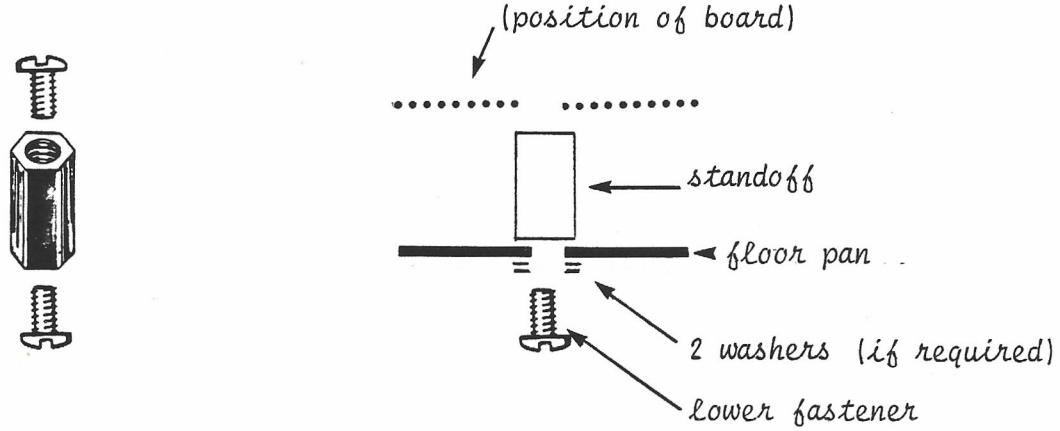


Fig. 10-1. INSTALLING A PLASTIC SPACER TO THE BOARD. N.B. AVOID USING METAL SPACERS IN THIS AREA!

b) Install one ¼ inch standoff (Fig. 10-2, A) at each corner of the floor. Use two nylon washers and one ¼ inch 4-40 screw as illustrated in Fig. 10-2, B.



A. this standoff can take one screw at each end

B. secure the standoff to to the floor

Fig. 10-2. A. A THROUGH-HOLE STANDOFF; B. INSTALLING THE STANDOFF.

c) Position the four corners of the motherboard over the four standoffs and secure the board at each corner with one washer and one screw. Adjust the standoffs to mate with the holes in the board. Tighten the bottom fasteners, then the top ones. Do not overtighten.

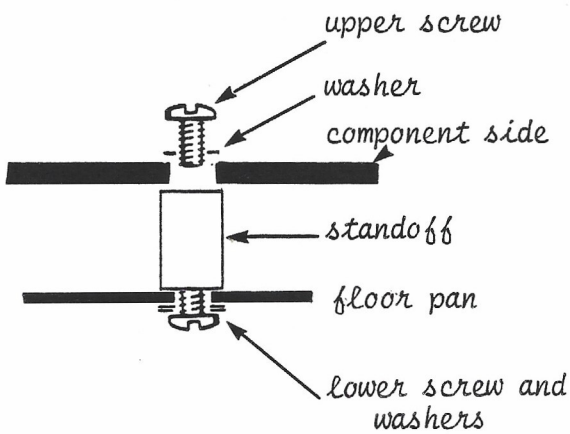


Fig. 10-3. SECURING THE MOTHERBOARD TO THE FLOOR OF THE CASE.

CAUTION DO NOT USE METAL SPACERS OR STANDOFFS IN AREAS WHERE SHORT CIRCUITS MAY OCCUR.

THE SPEAKER

Plug the speaker connector to the header pin and route the speaker wires around the bottom of the board to the opposite side. Secure the bottom of the speaker with 2-way adhesive tape to either the bottom of the case or to the top of the power supply.

THE KEYBOARD

1. Your keyboard may not fit the case if each one was purchased from a different supplier. Spacers and longer screws may be required to correctly position the keyboard.

2. Identify pin 1 of the 16-pin DIP keyboard connector. Label pin 1 with a very small dab of coloured nail polish for future reference.

3. Lower the keyboard with case over the circuit board. Match pin 1 of the keyboard connector to pin 1 of the keyboard socket and gently rock it into place.

4. Secure the case to the floor with screws and rubber feet previously removed.

THE MONITOR

Connect either a video monitor or a TV receiver to the connectors on the board. If an RF modulator is used, secure it to the side of the case with 2-way adhesive tape. Route the wires through one of the narrow slots at the back of the case.

THE GAME I/O CONNECTOR

1. Locate pin 1 of the DIP joystick connector. Identify it with a small dab of nail polish.

2. Match pin 1 of the connector with pin 1 of the game I/O connector and rock it into place.

3. Route the cable of the joystick through one of the slots at the back of the case.

11.

APPENDIX

ABBREVIATIONS

A	-Ampere
ASCII*	-American Standard Code for Information Interchange
APL*	-A Programming Language
B	-Base (transitor)
BASIC	-Beginner's All Purpose Symbolic Instruction Code
BIT	-Binary digIT
BYTE	-a group of 8 BITs
C	-Collector (transistor)
C	-letter code for capacitor
CAI*	-Computer Assisted Instruction
CMOS	-Complementary Metal-Oxide-Silicon
COBOL*	-COmon Business Oriented Language
CP/M*	-Control Program for Microprocessors
CPU	-Central Processing Unit
CRT	-Cathode-Ray Tube
D	-letter code for diode
DIP	-Dual In-line Package
DC	-Direct Current
E	-Emitter (transistor)
EEPROM	-Electrically Erasable PROM
EPROM	-Erasable PROM
FET	-Field Effect Transistor
FORTRAN*	-FORmula TRANslator
GND	-Ground
Hz	-Hertz
IC	-Integrated Circuit
I/O	-Input/Output
Kilobyte	-1,024 bytes
L	-letter code for coil
LED	-Light Emitting Diode

LS	-Low-power Shottky
MOS	-Metal-Oxide-Silicon
-ve	-negative
Pascal	-a noted French mathematician and philosopher (1623-62)
+ve	-positive
PC	-Printed Circuit
PCB	-Printed Circuit Board
PROM	-Programmable ROM
Q	-letter code for transistor
R	-letter code for resistor
RAM	-Random-Access Memory
RF	-Radio Frequency
ROM	-Read-Only Memory
SIP	-Single In-line Package
Trimcap	-Trim capacitor
Trimpot	-Trim potentiometer
TTL	-Transistor-Transistor Logic
UV	-Ultra Violet
xc	-crystal
XTAL	-crystal
Y	-letter code for crystal

METRIC PREFIXES -decimal points and large numbers are avoided.

p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
-	-	1.0^{1}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}

* are not discussed in the text